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Description

CONTROL METHOD FOR MOVING RACKS

BACKGROUND OF INVENTION

[0001] This invention relates to a method of controlling the movement of a moveable partition having at least a pair of transversely spaced, ground engaging drive elements for moving the partition along a parallel path.

[0002] Moveable partitions are used for many applications. For example one type of partition is a storage rack on which a variety of articles are placed. Frequently a plurality of these racks are positioned in a specific storage area. However fixed racks require more space than is acceptable in many applications.

[0003] It has been proposed, therefore, to mount the racks or partitions on rails by means of wheels so they can be moved into an abutting relation to free up space when access is not required to add or remove articles from a given rack. Then when access is required one or more racks may

be moved to create an access aisle. In fact it also has been proposed to power the racks for such movement.

[0004] However the use of tracks requires a dedicated area and adds to the cost. Therefore it has been proposed by applicant"s assignee to use a plurality of caterpillar like drive belts to support and move the partitions or racks and thus eliminate the need for guide rails. However when the racks have substantial width, a plurality of belts are required and at least some of them must be driven if they are to be powered and also to try to maintain parallel movement. Such an arrangement is shown in the assignee"s co-pending application Serial Number 10/248,686, filed February 9, 2003.

[0005] Even then, however, there is a possibility for the rack to stray from its intended course for a variety of reasons. To try to minimize such undesired straying from the intended path, the aforenoted application synchronizes all of the drives by providing a common drive shaft that interconnects all drives. However even when this is done such factors subtle displacement of the moving track after repeated reciprocating movements which may accumulate to an unacceptable level. Also, unbalanced loading of storage articles or mechanical errors may cause the rack

may move with inclination with respect to the desired traveling direction.

[0006] This problem can even occur with a movable rack that is guided by rails Again such factors as unbalanced loading of storage articles, variation in machining accuracy of parts of the drive section can result in a large load because of friction between wheels and rails. This can cause uneven or jerky movement along the rails.

[0007] It is therefore an object of this invention to provide a control method for a moving rack capable of moving without displacement in its moving path after repeated reciprocating movements and capable of eliminating oblique movement and meandering movement in spite of unbalanced loading of storage articles, mechanical working errors, or the like.

SUMMARY OF INVENTION

[0008] This invention relates to a moveable partition and method of controlling its movement. The partition has at least a pair of transversely spaced, ground engaging drive elements for moving the partition along a parallel path.

[0009] The method comprises the steps of sensing the path of movement of the partition and controlling the drive elements to maintain a parallel path of movement.

[0010] The partition has a control that senses the path of movement of the partition and controls the drive elements to maintain a parallel path of movement.

[0011] In accordance with another feature of the invention, a structure of the type described above is operated to maintain the parallel control only if the path of movement deviated from parallel by more than a predetermined amount.

[0012] In accordance with a still further feature of the invention the previously described structure has a position sensor for determining that an undesired object is between two partitions and the movement of the partitions is stopped but only after correction of the position of one partition has been accomplished.

Brief Description of Drawings

[0013] FIG. 1 is a top plan view of one end of a partition mounting base constructed and controlled in accordance with the invention.

[0014] FIG. 2 is a longitudinal cross sectional view of the end shown in FIG. 1.

[0015] FIG. 3 is a top plan view of the central portion of the partition mounting base.

[0016] FIG. 4 is a longitudinal cross sectional view of the portion

shown in FIG. 3.

[0017] FIG. 5 is a top plan view of the other end of the partition mounting base.

[0018] FIG. 6 is a longitudinal cross sectional view of the end shown in FIG. 5.

[0019] FIG. 7 is a transverse cross sectional view of both of the partition mounting base ends.

[0020] FIG. 8 is a transverse cross sectional view of the central portion of the partition mounting base ends.

[0021] FIG. 9 is an enlarged cross sectional view looking in the same direction as FIGS. 2 and 5 taken through the axis of the base drive.

[0022] FIG. 10 is a perspective view of a sensor used in connection with the invention.

[0023] FIG. 11 is a top plan view of a moveable panel utilizing the sensor of FIG. 10 in one course of control.

[0024] FIG. 12 is a top plan view, in part similar to FIG. 11 showing the moveable panel in another course of control.

[0025] FIGS. 13a, 13b and 13c are schematic top plan views showing various control conditions that may exist in panel movement.

[0026] FIG. 14 is a graphical view showing the various control judgments made to maintain parallel panel movement.

[0027] FIGS. 15a, 15b and 15c are in part similar to FIGS. 13a, 13b and 13c and are schematic top plan views showing various control conditions that may exist in panel movement.

[0028] FIG. 16 is a graph showing how the control parameters are determined.

[0029] FIGS 17a, 17b and 17c are in part similar to FIGS. 13a, 13b and 13c and FIGS. 15a, 15b and 15c and are schematic top plan views showing other control conditions that may exist in panel movement and utilizing a different sensor arrangement.

[0030] FIG. 18 is a graph showing how the control parameters are determined.

[0031] FIGS. 19a, 19b and 19c are in part similar to FIGS. 17a, 17b and 17c are schematic top plan views showing other control conditions that may exist in panel movement and utilizing the different sensor arrangementFIG. 20 is a graph showing how the control parameters are determined.

[0032] FIG. 21 is a front elevational view of a rack constructed and operated in accordance with another embodiment of the invention.

[0033] FIG. 22 is a partially perspective view of the sensor ar-

rangement shown in FIG. 21.

[0034] FIG. 23 is a front elevational view in part similar to FIG. 21 and shows another embodiment that utilizes a contact type sensor.

[0035] FIG. 24 is a side elevational view of this embodiment showing how a plurality of racks can employ the invention and shows the racks converged relative to each other.

[0036] FIG 25 is a top plan view showing the locations of the position sensors.

[0037] FIG 26 is an enlarged front elevational view showing the position sensor.

[0038] FIG 27 is a side elevational view showing the position sensors.

[0039] FIG 28 is a further enlarged view of the position sensor showing it in a normal position in solid lines and in displaced positions in phantom lines.

[0040] FIG. 29 is an electrical diagram for explaining how the position sensor provides an output signal.

[0041] FIG. 30 is a top plan view of a partition system constructed and operated in accordance with another embodiment of the invention.

[0042] FIG. 31 is an enlarged view of the area in the circle 31 in FIG. 30.

[0043] FIG. 32 is an enlarged view of the area in the circle 32 in FIG. 30.

[0044] FIG. 33 is a top plan view, in part similar to FIG. 30,and shows a still further embodiment.

DETAILED DESCRIPTION

[0045] Unknown;Referring now in detail to the drawings and initially to FIGS. 1-10, a moveable drive base for a partition which may comprise, for example a storage rack, indicated generally at 51, is comprised of a base frame,indicated generally at52, and fabricated from a suitable material such as metal plates, made of iron or the like and bent in the shape of a letter U or L in section, assembled in a frame-like shape. The base frame 52contains and supports assembled running wheel shafts, their rotational drive mechanisms, and the like to be described in more detail shortly.

[0046] The base frame 52 has a considerably long length as compared to its width. Supported at its ends and in its central portion arepairs of transversely extending saddles 53 formed in the shape of an inverted character "Ω" viewed from the side. Bearings or pillow blocks 54 are fixed between the saddles 53. The end pair of bearings 54 journal drive shafts 55. Parallel to these drive shafts 55,

follower shafts 56 are journalled by these pairs of bearings 54.

[0047] At the outer ends of the frame 52, a drive wheel 57 is fixed to each of the drive shafts 55 between the pair of saddles 53, as best seen in FIG. 7. To power each of the drive shaft 55, a gear 58is fixed at the outer side of one of the saddles 53. An electric drive motor59 is fixed through an appropriate support member adjacent each of the gears. A pinion 61is fixed to the output shaft of the motor 59 and the pinion meshes with the gear 58 to drive it and the drive wheel 57. Preferably the motor 59has an integral transmission for reducing the rotational speed of the motor 59 and the output is further reduced by the pinion 61 and gear 58to provide more driving power.

[0048] As seen in FIG. 7, the follower shaft 56is disposed parallel to the drive shaft 55 in the direction of travel of the moving rack 51. A follower wheel 62is fixed to the follower shaft 56 between the pair of saddles 53. The follower wheel 62 has the same diameter as the drive wheel 57.

[0049] A belt-like endless track member 63 is entrained around the drive wheel 57 and the follower wheel 62. The endless track member 63 is in contact with the surface of a floor 64upon which the moving rack 51supported. Thus when

the drive motors 59 are operated the belts will drive the partition 51 along the floor 64 through the operation of the track members 63.

[0050] Although they are not powered, similar belt track members 63 and supporting wheels along with bearings and shafts are positioned at selective places along the frame assembly 52 to support the weight of the partition between the driven ones at the ends of the frame assembly as shown in FIGS. 3, 4 and 8. Because the structures are otherwise the same as the driven ones like reference numerals have been utilized to designate like parts. For this reason it is not believed necessary to further describe these additional supporting arrangementsA control circuit and circuit board, indicated by the reference numeral 65, and shown in FIGS. 1 and 2 is mounted at one end of the frame assembly 52 for controlling the operation of the motors 59. This structure and the method by which it operates will be described in detail later.

[0051] Thus as described above, the endless track member 63 is wrapped around the outer circumferential surfaces of the drive wheel 57 and follower wheel 62, so that the drive wheel 57 and follower wheel 62 are connected by the endless track member 63. The drive wheel 57 is driven for

rotation by the motor 59both in forward and reverse directions, so the moving rack 51 runs on the floor 64. The non-driven pair of follower wheels 62 and the endless track member 63 wrapped around these follower wheels 62 as shown in FIGS. 3, 4 and 8 thus also rotate when the moving rack 51 is moved.

[0052] Preferably the endless track member 63 wrapped around the outer circumferential surfaces of the drive wheel 57 and follower wheel 62of the driven and non-driven pairs are toothed belts to prevention of sliding over the drive wheel 57 or the follower wheel 62, and the drive wheel 57 and the follower wheel 62 are wheels each having complimentary grooves into which the teeth of the track member63 are fitted. Even so, however, there is a possibility that the endless track member 63 will be displaced in the axial direction with respect to the drive wheel 57 and follower wheel 62. Therefore it is desirable that some kind of displacement prevention means is provided. This could be done by providing flanges on both edges of the drive wheel 57 and follower wheel 62. However, in a system in which the endless track member 63 is in contact with the floor surface as in this invention, the amount of projection of the flanges must be smaller than the thickness of the

endless track member 63. This may not be sufficient to prevent axial displacement of the endless track member 63.

[0053] Therefore the structure shown in FIG. 9 is preferably adopted as a displacement prevention measure of the endless track member 63. As seen there, the underside of the base frame 52 of the moving rack are fixed L shaped angle members 67 one side of which extends vertically downwardly along the side surface of the endless track member 63. Such angle members 67 are fixed in a pair, with one side each of these angle members 67 along the side surfaces of the endless track member 63. The pair of angle members 67 may run along both sides of the drive wheel 57and/or follower wheel 62.

[0054] Since the endless track mechanisms 63 cause the moving rack 51 to run in the direction of the endless track member 63, the moving rack 51 can be moved in a straight line in the direction perpendicular to its front face. Therefore, the moving rack 51 may be placed directly on the floor surface, and guide rails need not employed. That is, a rail-less moving rack is achieved. Also, because the load of the moving rack 51 itself and the load exerted on the moving rack by articles stored in the moving rack are sup-

ported by the running track mechanisms including those that are not driven, the load exerted on a unit area of the floor becomes small, so that the moving rack can be installed without need of floor reinforcement.

[0055] However a problem may arise that other factors, examples of which will be given later may cause the rack 51 to travel in a less than parallel path and one that may become skewed. To avoid this it has been proposed in commonly assigned application Serial Number 10/248,686, filed February 9, 2003, to connect all of the drive shafts to each other so as to move the rail-less rack in a straight line. However, because of errors in the working accuracy of parts, unbalanced loading of storage articles, and the like, the moving track can be displaced subtly upon successive movement or the moving rack can move obliquely or meanderingly.

[0056] Thus, in this invention, drive mechanisms each having a drive wheel 57 and an endless track member 63 are provided independently on both the ends of the moving rack 51. Displacement with respect to a reference body extending in the moving direction of the moving rack 51 is detected by a sensor provided on the moving rack 51, and the separate drive mechanisms, and specificallytheir drive

motors 59, are controlled independently in response to the displacement detected. This allows the moving rack 51 to reciprocate following a defined path at all times.

[0057] FIG. 10 shows an example of an optical sensor unit for use as a sensor in this invention. As seen in FIG. 10, a guide pattern 68 is marked on the surface of a floor on which a moving rack 51 is installed as a reference body for detecting the displacement of the moving rack. The guide pattern 68 is made of a material having a high contrast with respect to the floor surface on which it is marked, or of a material having a high light reflectivity compared to that of the floor surface. The guide pattern 68 may be marked with paint, or may be a tape affixed to the floor. Alternatively a steel plate or the like may be used. In any event, the guide pattern 68 should have clear edges on both sides.

[0058] A sensor unit, indicated generally at69, is disposed above the guide pattern 68 in an opposing relation. The sensor unit 69 has a pair of light sources 71 and72, which are adapted to illuminate the guide pattern 68 near its outer edges. The light sources 71 and 72 may be, for example, lamps, LEDs or the like.

[0059] The sensor unit 69 also has a pair of light receiving ele-

ments 73 and 74. The light receiving elements 73 and 74 receive the reflected light from the guide pattern 68 near its edges. The light sources 71 and 72 are disposed to illuminate the light receiving areas of the light receiving elements 73 and 74, respectively. For the light receiving elements 73 and 74, photodiodes, phototransistors, solar batteries and other appropriate light sensitive elements can be used.

[0060] Referring now to FIGS. 11 and 12, these show schematically the application of the sensor 69 to a the rail-less moving rack 51 having a structure of the type shown in FIGS. 1-9. As already noted, the rack 51 is provided with endless track members 63with electric motors 59 as their drive sources operated independently on both ends. In order to detect the edges of the guide pattern 68 marked in the moving direction of the moving rack 51, two sensor units 69 are disposed at the front and the rear of the moving rack 51 in its moving direction. Each of the sensor units 69 has light receiving elements 73 and 74 for detecting the edges of the guide pattern 68. The light receiving elements 73 and 74 in this embodiment are of a type which detects the amount of reflected light.

[0061] As also noted previously control means independently

control the left and right motors 59 according to the output of the sensor unit on the forward side in the moving direction of the moving rack 51 and that of the sensor unit on the rear side. The control means is incorporated in the control circuit board 65 (not shown in these figures), and can be constituted by a circuit including, for example, a microcomputer made up of a microprocessor, a ROM, a RAM and the like. The control operation of the control means will be described shortly.

[0062] This embodiment is characterized in that the left and right drive motors 59 are basically controlled independently according to the output of the sensor unit 69 on the forward side of the moving rack in the moving direction and the output of the sensor unit 69 on the rear side. In the example shown in FIGS. 11 and 12, by detecting the ratio of the amount of received light of one light receiving element 73 to the amount of received light of the other light receiving element 74 of the sensor unit 69 on the forward side of the moving rack 51 in the moving direction, the left and right motors 59 are controlled such that a ratio of the amount of received light of one light receiving element 73 to the amount of received light of the other light receiving element 74 of the sensor unit 69 on the forward

side of the moving rack 51 in the moving direction becomes equal.

[0063] The control method will be explained more specifically by reference to FIGS. 13a, 13b and 13c along with FIG. 14. First, control is performed such that the amounts of received light of the light receiving elements 73 and 74 of the sensor unit 69 on the forward side in the moving direction become equal. Here, it is assumed that the amounts of received light of the light receiving elements 73 and 74 are set such that they become equal when both edges of the guide pattern 68 cross the centers of the light receiving areas of the light receiving elements 73 and 74.

[0064] For simplicity, in FIGS.13a, 13b and 13c and in FIG.14, the light receiving element 73 is designated as "1" and the light receiving element 74 as "2." If both the edges of the guide pattern 68 are crossing the centers of the light receiving areas of the light receiving elements 1, 2 as shown in FIG. 22a, the outputs of the light receiving elements 1,2 are both moderate, as shown in the column a of FIG.14, control of the left and right motors 59 need not be corrected, and the judgment is "OK." Then the control of the left and right motors 59 is equal as shown in FIG. 11.

[0065] However, if the light receiving areas of the light receiving elements 1, 2 are displaced to the right with respect to the guide pattern 68 as shown in FIG.13b, the light receiving element 1 on the left side as viewed in the moving direction receives more reflected light from the guide pattern 68 while the light receiving element 2 on the right side receives less reflected light from the guide pattern 68, then the output of the light receiving element 1 becomes "large" and that of the light receiving element 2 becomes "small," as shown in the column b of FIG.14. Since this shows that the moving rack 51 is biased to the right as viewed in the moving direction. This operation is shown in FIG. 12. The moving rack 51 is moved to the left until the condition shown in FIG.13a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the right motor 59.

[0066] On the other hand, if the light receiving areas of the light receiving elements 1, 2 are displaced to the left with respect to the guide pattern 68 as shown in FIG.13c, the output of the light receiving element 1 becomes "small" and that of the light receiving element 2 becomes "large," as shown in the column c of FIG.14. Since this shows that

the moving rack 51 is biased to the left as viewed in the moving direction, the moving rack 51 is moved to the right until the condition shown in column a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the left motor 59.

[0067] In this way, control is performed such that the outputs of the light receiving elements 1, 2 of the sensor unit on the forward side in the moving direction have a predetermined value, and then the left and right motors 59 are controlled independently such that the outputs of the light receiving elements 1, 2 of the sensor unit on the rear side in the moving direction coincide with each other.

[0068] FIGS. 15a, 15b and 15c and FIG. 16illustrate how this control is performed. In conditions shown in FIGS. 15a, 15b and 15c, the position of the moving rack 51 in the lateral direction is controlled as mentioned above, and the outputs of the light receiving elements 1, 2 of the sensor unit on the forward side in the moving direction coincide with each other. In the condition shown in FIG. 15a, the outputs of the pair of light receiving elements 1, 2 of the sensor unit on the rear side in the moving direction also coincide with each other and the moving rack 51 is posi-

tioned in a predetermined place, so that a judgment can be made that oblique movement or meandering movement hasn't occurred. Therefore, the judgment is "OK" as shown in the column a of FIG, 16, and control of the left and right motors 59 need not be corrected.

[0069] On the contrary, as shown in FIG. 15b, the pair of light receiving elements 1, 2 of the sensor unit 69 on the rear side in the moving direction are displaced to the right with respect to the guide pattern 68 as viewed in the moving direction. In this case, as shown in the column b of FIG. 16, the output of the light receiving element 51 becomes large and that of the light receiving element 2 becomes small, so that a judgment can be made that the moving rack is moving obliquely to the left. Then, inclination of the moving rack 51 is corrected until the condition shown in FIG. 15a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the right motor 59.

[0070] Also, suppose that, as shown in FIG. 15c, the pair of light receiving elements 1, 2 of the sensor unit 69 on the rear side in the moving direction are displaced to the left with respect to the guide pattern 68 as viewed from the moving direction. In this case, as shown in the column c in

FIG. 16, the output of the light receiving element 1 becomes small and that of the light receiving element 2 becomes large, so that a judgment can be made that the moving rack is moving obliquely to the right. Then, inclination of the moving rack 51 is corrected until the condition shown in FIG. 15a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of left motor 59.

[0071] As described above, if the left and right motors 59 are controlled according to the output of the sensor unit 69 on the rear side in the moving direction, the position of the sensor unit 69 on the forward side in the moving direction with respect to the guide pattern 68 is displaced. Thus, the moving rack is controlled to a condition in which no oblique movement occurs by repeating the control according to the output of the forward sensor unit 69 and that according to the output of the rear sensor unit 69.

[0072] To summarize regarding the control of the moving rack 51, first the outputs of the left and right light receiving elements on the forward side are compared and unless they coincide, the left and right drive motors59 are controlled independently until coincidence is achieved. Then outputs

of the left and right light receiving elements on the rear side in the moving direction are compared; and unless they coincide, the left and right drive sources are further controlled independently until coincidence is achieved. In this way, by controlling independently the left and right drive sources according to the outputs of the light receiving elements on the forward and rear sides in the moving direction, control accuracy is improved and, as a result, oblique movement and meandering movement is prevented.

[0073] These controls can be performed with appropriate control means, for example, control means constituted by a microcomputer with a central processing unit (CPU), a read only memory (ROM) in which programs are stored, a random access memory (RAM) in which data is stored, and the like. In such control means, the CPU compares or calculates detected signals from the sensors, and the program is designed so that the left and right drive sources are controlled independently according to the processing result of the CPU until the detected outputs of the sensors coincide.

[0074] Now, description will be made on a variant of the sensor unit, and a control device and a control method for a

moving rack using the variant. Referring first to FIG. 17, first and second light receiving element groups mounted on the forward side of the moving rack 51 are identified by the reference numerals 75 and 76. Each of the light receiving element groups 75 and 76 is made up of a pair of light receiving elements. The light receiving elements of the first light receiving element group 75 are designated as 1, 2 and those of the second light receiving element group 76 as 3, 4. The light receiving areas of the light receiving elements 1, 2 are in contact with each other transversely. These light receiving areas lie near the left edge of the guide pattern 68. On the other hand, the light receiving areas of the light receiving elements 3, 4 are also in contact with each other laterally, and these light receiving areas lie near the right edge of the guide pattern 68.

[0075] Figure 18 depicts the control parameters utilized in this system and method. Column a of FIG. 18 shows the outputs of the light receiving elements 1, 2, 3, 4 when the left edge of the guide pattern 68 is on the contact point of the light receiving areas of the light receiving elements 1, 2 of the first light receiving element group 75 and the left edge of the guide pattern 68 is on the contact point of the light receiving areas of the light receiving elements 3, 4 of

the second light receiving element group 76, as shown in FIG. 17a. Here, the amount of received light is differentiated according to whether it is higher than a certain level, in a medium level or lower than the medium level. These outputs are represented by "0" if higher, by "Δ for a medium level, and by "×" if lower.

[0076] If the outputs of the light receiving elements 1, 2, 3, 4 are represented by "×OO×," as shown in the column a of FIG. 18, a judgment is made that there is no lateral displacement of the moving rack and position correction control need not be performed.

[0077] On the other hand, where the outputs of the light receiving elements 1, 2, 3, 4 are represented by "ΔOΔ×," as shown in the column b of FIG. 18, the moving rack 51 is in a condition in which it is displaced to the left at the forward side in the moving direction, as shown in FIG. 17b. Then, as in the foregoing control, the moving rack 51 is moved to the right until a predetermined position shown in FIG. 17a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the right motor 59.

[0078] On the other hand, in the case where the outputs of the light receiving elements 1, 2, 3, 4 are represented by

"×ΔOΔ," as shown in the column c of FIG. 18, the moving rack is in a condition in which it is displaced to the right at the forward side in the moving direction, as shown in FIG. 17c. Then, as in the foregoing control, the moving rack 51 is moved to the left until a reference position shown in FIG. 17a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the left motor 59.

[0079] Referring now toFIGS 19a, 19b and 19c, two light receiving element groups 75 and 76 having the same structure as the foregoing sensor unit are mounted on the rear side of the moving rack 51. A first light receiving element group 75 has light receiving elements 1, 2, and a second light receiving element group 76 has light receiving elements 3, 4. The light receiving areas of the light receiving elements 1, 2 are in contact with each other laterally and these light receiving areas lie near the left edge of the guide pattern 68. The light receiving areas of the light receiving elements 3, 4 are also in contact with each other laterally, and these light receiving areas lie near the right edge of the guide pattern 68.

[0080] If, as shown in FIG.19(a), the left edge of the guide pattern 68 is on the contact point of the light receiving areas of

the light receiving elements 1, 2 of the first light receiving element group 75 and the right edge of the guide pattern 68 is on the contact point of the light receiving areas of the light receiving elements 3, 4 in the second light receiving element group 76, outputs of the light receiving element groups 75 and 76 on the rear side in the moving direction of the moving rack become the same as those of the light receiving element groups 75 and 76 on the forward side in the moving direction of the moving rack. At this time, the outputs of the light receiving elements 1, 2, 3, 4 of the sensor units 75 and 76 on the rear side in the moving direction are represented by "×OO×," as shown in the column a of FIG. 20, and a judgment is made that the moving rack has a posture without oblique movement so that correction control of the left and right motors 59 is not needed.

[0081] On the other hand, if, as shown in FIG.19b, the rear side of the moving rack in the moving direction is displaced to the right with respect to the moving direction, outputs of the light receiving elements 1, 2, 3, 4 on the rear side in the moving direction are represented by "ΔOΔ×" as shown in the column b of FIG.20. A judgment can be made from the outputs that the moving rack is inclined obliquely to

the left. Then, control is performed until the reference position shown in FIG.19a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the right motor 59, for the correction of the inclination.

[0082] On the other hand, if as shown in FIG.19c, the rear side of the moving rack in the moving direction is displaced to the left, outputs of the light receiving elements 1, 2, 3, 4 on the rear side in the moving direction are represented by "×ΔOΔ" as shown in the column c of FIG. 20. A judgment can be made from the outputs that the moving rack is inclined obliquely to the right. Then, control is performed until the reference position shown in FIG.19a is achieved, for example, by controlling speeds of the left and right motors 59 or by temporarily stopping the drive of the left motor 59, for the correction of the inclination.

[0083] Thus with this embodiment, by the control of the left and right motors 59 on the rear side, the light receiving elements 1, 2, 3, 4 constituting the light receiving element groups 75 and 76 on the forward side in the moving direction are displaced from the reference position with respect to the guide pattern 68, so that the moving rack is controlled to a condition in which no oblique movement

occurs by repeating the control according to the outputs of the forward light receiving element groups 75 and 76 and that according to the outputs of the rear light receiving element groups 75 and 76. As control means for performing such control, a microcomputer such as mentioned previously can be used.

[0084] In the control method and the control device for a railless moving rack having light receiving element groups 75 and 76 as shown in FIG. 17 and FIG.19, since edges of the guide pattern 68 are observed at all times as to whether they are positioned between paired light receiving elements, even slight positional displacement can be detected from the difference in detected outputs from the paired light receiving elements. This allows fine control of the left and right motors 59, thereby correcting positional displacement, oblique movement and meandering movement of the moving rack within a very small range.

[0085] As thus far described the guide pattern has been on the floor. However the guide pattern may be provided above the moving rack 51, an example of which is shown in FIG. 21 and FIG. 22. FIG. 21 actually is the first figure showing the partition structure above the base 52. Since the structure of the base 52 is the same as previously described

except for the sensor location, it will not be described further.

[0086] As seen in FIG. 21 and FIG. 22, sensor units 77 are attached on a top plate 78 of the moving rack 51. The construction of the sensor unit 77 may be the same as any one of the foregoing embodiments. Above the sensor units 77 are fixed, arranged in the moving direction of the moving rack, hangers79that are connected to the ceiling, beams, posts or opposing walls, and other appropriate structural bodies of the building in which the moving rack 51 is installed. A member (not shown) protruding upwardly from the moving rack 51 engages with and moves along the hangers 79, to insure that the moving rack 51will be maintained upright. The bottom of the hangers79 faces the sensor unit 77, and a guide pattern 80 of any type as aforedescribed is placed on the bottom of the hanger79.

[0087] As shown in FIG. 22, the sensor unit 77 has a light emitting section 81 for emitting illumination light toward the guide pattern 80 and a light receiving section 82 for receiving the reflected light of the illumination light from the guide pattern 80. The light receiving section 82 may be made up of a light receiving element of a type for de-

tecting the amount of reflected light from the guide pattern 80 as shown in FIG. 10 or that of a type for detecting left and right edges of the guide pattern 80 as shown in FIG. 17.

[0088] Now, an embodiment using a mechanical sensor as the sensor will be described with reference to FIG.23 through FIG.29. Referring first to FIG.23 and FIG.24, these show the exterior of a moving rack according to this embodiment which is again identified generally by the reference numeral 51. The rack 51 has mechanical sensors 83, of a type to be described later, attached to the top plate 78. Hanger receivers 84 fixed in the direction of depth of the moving rack 51 to cover the sensors 83. The hanger receivers84are channel type membershaving a hat shape in section.

[0089] A hanger85 extends through the hanger receiver 84 in the horizontal moving direction of the moving rack 51. The hanger85 is made of a pipe of a rectangular shape in section and is supported by appropriate supporting means (not shown), for example, between a pair of fixed racks or by a wall or ceiling of the building in which the moving rack 51 is installed. Typically, a plurality of moving racks 51 are arrangedon common hangers 85 so that they can

be mover adjacent each other as shown in FIG. 24 or separated. The hanger85 extends through hanger receivers 84 of the moving racks 51that constitute one unit. The running mechanism or the drive mechanism of the moving rack 51 has the same construction as those shown in FIGS.1 through 9 previously described. In FIG.25 through FIG.27, the numeral 86 designates a post and numeral 87 a side panel, respectively, of the moving rack 51.

[0090] The construction of the sensor 83 will be described in more detail particularly by reference toFIGS.25-27. A base plate 88is fixed on the top plate 78 of the moving rack 51and extends horizontally. Mounted on the base plate 88 are hanger receiver lower members 89, each bent in a hat shape, at the forward and rear ends of the moving rack 51. These hanger receiver lower members 89 are covered by both forward and rear ends of the hanger receiver 84. The left and right ends of the hanger receiver lower members 89 and the hanger receiver 84 are fixed to the base plate 88 by suitable threaded fasteners.

[0091] The hanger 85passes through spaces surrounded by the hanger receiver 84 and hanger receiver lower members 89 with a clearance between the hanger receiver 84 and hanger receiver lower members 89. The moving rack 51

usually moves with the hanger receiver 84 and hanger receiver lower members 89out of contact with the hanger85because this structure is provided primarily for safety purposes to prevent falling. However, but if the moving rack 51becomes inclined by some cause, the hanger receiver 84 or the hanger receiver lower members 89 come in contact with the hanger85 and the moving rack 51 is prevented from falling.

[0092] Window holes 91 (FIG. 27) are formed on one side of the hanger receiver 84 at positions near the forward and rear ends so that the placement of the mechanical sensors 83 is not obstructed. For the arrangement of the sensor 83, a pair of support plates 92 rise up across each of the window holes 91 and face each other.

[0093] A variable resistor 93 as a sensor body is fixed to one of the paired support plates 92, and a rotation control shaft 94 of the variable resistor 93 is supported for rotation by the other support plate 92. A lever 95extends upwardly from the rotation control shaft 94 rises up a integrally toward one side of the hanger85. At the head, or the top, of the lever 95 is mounted a flat roller 96 for rotation with the lever 95. The rotation control shaft 94and the lever 95are biased by appropriate biasing means such as a

spring or the like to hold the roller 96 in contact with one side of the hanger 85 at all times. These support plates 92, variable resistor 93 and roller96 are partially exposed to the outside of the hanger receiver 84 through the window hole 91. Thus the components including the support plates 92, variable resistor 93, roller 96 and lever 95 constitutes the mechanical sensor 83. Sensors 83 are disposed at the front and the rear of the moving rack 51.

[0094] Because the mechanical sensor 83 is configured as described, if the relative position of the moving rack 51 to the hanger85is displaced laterally, the distance between the side of the hanger85 and the roller 96 changes, resulting in pivotal movement of the lever 95. Thus, the hanger85 serves as a reference body for detecting the displacement of the moving rack. FIG.28 shows how the lever 95cam be inclined in either direction. When the moving rack 51 is in a reference position with respect to the hanger85, the lever 95 is adjusted such that it has an upright posture as shown in FIG.28 by solid lines. If the moving rack 51 is biased from the reference position toward the left, the lever 95 is inclined toward the right in FIG.28, and if the moving rack 51 is biased from the reference position toward the right, the lever 95 is inclined

toward the left in FIG.28. Because the rotational position of the rotation control shaft 94 of the variable resistor 93changes depending on the inclination of the lever 95, the resistance value of the variable resistor 93 will change.

[0095] As seen in FIG.29, a certain voltage Vcc is applied to a variable resistor 93 between its terminals to form a potentiometer. An output voltage Vo is be obtained from the variable output terminals in response to the position of a moving contact. This output voltage Vo is a detected output of the mechanical sensor 83. When only the output voltage Vo is set as a reference when the moving rack 51 is at a reference position, if the lever 95 is inclined to the left or the right as shown in FIG.28 by broken lines, the output voltage Vo changes from a reference value to a plus or minus one. Thus, the lateral direction in which the moving rack 51 is displaced can be detected from changes in the output voltage Vo, and the motors 59 as the left and right drive sources are controlled independently in response to this detected signal to bring the output voltage Vo into coincidence with a reference value, thereby eliminating positional displacement or oblique movement of the moving rack 51.

[0096] The embodiments thus far described are of a systems in

which displacement with respect to a reference body lying in the moving direction of a moving rack is detected by sensors provided on the rack and in which left and right drive sources are controlled independently in response to the displacement detected by the sensors. In such control method, the left and right side drive sources are independently controlled such that, if the rack moves obliquely, the sensors detect the oblique movement to issue an order to correct it. Therefore, the rack moves with little or no oblique movement. However, since control operations to correct the oblique movement, that is, speed control operations of the drive wheels provided independently on the left and right sides of the rack are performed separately and at all times, it is conceivable that the rack may jerk in its movement with its left and right sides moving ahead or behind with respect to each other. To eliminate such a disadvantage, an arrangement may be preferably adopted such as shown in the following embodiment of FIGS. 30-33.

[0097] The arrangement of this embodiment is the same as that in any of the foregoing embodiments in that drive wheels and their drive sources are provided independently on the left and right sides of the rack. It is also the same in that

displacement with respect to a reference body is detected by sensors provided on the moving rack. However, the sensors are configured to detect the degree of displacement with respect to the reference body to detect the amount of oblique movement of the moving rack.

[0098] In accordance with this embodiment, a control such as a CPU and the like is arranged such that the left and right drive sources are controlled independently at the same rotational speed in a "parallel movement mode" if the amount of oblique movement detected by the sensors is within a tolerable range. However the left and right drive sources are controlled independently at different rotational speeds to eliminate the oblique movement in an "oblique movement correction mode" if the amount of oblique movement detected by the sensors is beyond the tolerable range.

[0099] The "parallel movement mode" is an operation mode in which drive sources provided independently on the left and right sides are speed-controlled to drive left and right wheels at the same speed as each other for a parallel movement of the moving rack. The "oblique movement correction mode" is an operation mode in which the rotational speed of the drive wheel on the side of the moving

rack moving ahead in the moving direction is lowered, or in which that of the drive wheel on the side moving behind is increased.

[0100] Referring now specifically to FIGS. 30 to 33, two adjacent racks are each identified generally by the same reference numeral 101. In FIG. 30 the rack 101 on the right side is in the desired posture perpendicular to its moving direction and without any oblique movement. However the rack 101 on the left side is moving obliquely or skewed with respect to the moving direction. Each moving rack 101 is provided with a drive 63 and drive motors 59, as previously described. The same reference numerals are used to identify these components as previously applied inasmuch as these components are the same as previously described. The motors 104 59 are speed-controlled to be driven for rotation at the same speed as each other by any suitable control means for the parallel movement of the racks 101. This operation mode is the "parallel movement mode" previously mentioned.

[0101] The two racks 101 are associated with two reference bodies 102 that extend in the moving direction of the racks 101 and are parallel to each other at a given interval. The reference body 102 has the same function as the refer-

ence body in the foregoing embodiments and may be provided below the moving rack 101, that is, on the floor on which the moving rack is installed, or above the moving rack 101. In the illustrated example, it is provided above the moving rack 101.

[0102] Each moving rack 101 has a pair of sensors 103 and 104 for detecting displacement with respect to one of the reference bodies 102. For the detection method of the sensors 103 and 104 in this embodiment, a mechanical sensor of the same principle as the mechanical sensor shown in FIGS.24- 29 is used, but the invention is not so limited.

[0103] That is and as shown in FIG. 32, referring to one of the sensors, 103, it has a fixed member 105 fixed to the moving rack 101 and a lever rising up for swinging movement from the fixed member 105 and biased such that a roller 106 at the top is in contact with one side surface of the reference body 102. The other of the sensors, 104, likewise, has a fixed member 107 fixed to the moving rack 101 and a lever rising up for swinging movement from the fixed member 107 and biased such that a roller 108 at the top is in contact with one side surface of the reference body 102.

[0104] The paired sensors 103 and 104 are disposed at the front

and the rear of the moving rack 101 at a given spacing. These sensors 103 and 104, like the mechanical sensors in the foregoing embodiment, have a variable resistor whose resistance value changes in response to the inclination angle of the lever, and this constitutes a potentiometer arranged such that the output voltage changes in response to the inclination angle of the lever.

[0105] If a moving rack, like the moving rack 101 shown in FIG.30 on the right side, is perpendicular to the reference body 102 without inclination, the paired sensors 103 and 104 have the same posture as shown in FIG.31 and the levers of the sensors stand approximately upright. Therefore, the difference in output between both sensors is approximately 0 V.

[0106] On the other hand, if a moving rack is, like the moving rack 101 shown in FIG.30 on the left side, inclined with respect to the reference body 102 because of its oblique movement, the both levers of the paired sensors 103 and 104 are inclined in a certain direction as shown in FIG.32. However, since the paired sensors 103 and 104 are disposed at a certain distance apart in the moving direction, the amounts of inclination of the levers of the paired sensors 103 and 104 differ, causing a difference in output

between the both sensors 103 and 104. Then, if the output of one of the sensors is subtracted from that of the other, the direction of the inclination of the moving rack can be judged from the subtraction result, which is plus or minus, and the magnitude of the inclination from the difference in output between the both sensors.

[0107] Thus, in this embodiment, the amount of inclination of the moving rack which can be detected from the outputs of the sensors, that is, the amount of oblique movement is detected, and if the amount of oblique movement detected is within a tolerable range, the left and right drive sources are controlled independently in the foregoing "parallel movement mode." Also, if the amount of oblique movement detected is beyond the tolerable range, the left and right drive sources are controlled independently in the foregoing "oblique movement correction mode" to eliminate the oblique movement. Specifically, the motors 59 disposed independently on the left and right sides of the moving rack are controlled such that the side moving behind moves faster than the side moving ahead. The motor on the side moving ahead may be decelerated, the motor on the side moving behind may be accelerated, or speeds of the both motors may be simultaneously con-

trolled.

[0108] In the embodiment described above, since, when the moving rack is driven in the "parallel movement mode," the rotational speeds of the motors are kept constant and control of accelerating/decelerating the left and right sides of the moving rack 101 is not performed, the moving rack 101 moves smoothly without jerk. If oblique movement is within a tolerable range, the moving rack still makes a parallel movement while maintaining the oblique movement within a tolerable range.

[0109] Even if the moving rack 101 moves obliquely because of biased loading after repeated reciprocating movements, the moving rack is driven in the "parallel movement mode" as long as the amount of oblique movement detected is within a certain tolerable range. It is not until the amount of oblique movement is beyond the certain tolerable range that control operation is performed in the "oblique movement correction mode" to eliminate the oblique movement.

[0110] If the oblique movement is corrected to within the tolerable range, the moving rack is driven again in the "parallel movement mode." Here, it is preferable that a hysteresis is provided between the switching point from the "parallel

movement mode" to the "oblique movement correction mode" and that from the "oblique movement correction mode" to the "parallel movement mode." For example, it is preferable that, if oblique movement is beyond a certain tolerable range, control is switched over to the "oblique movement correction mode," and that, in the "oblique movement correction mode," control is not switched over to the "parallel movement mode" immediately when the oblique movement falls within the tolerable range, but is switched to the "parallel movement mode" when the oblique movement is practically eliminated.

[0111] In a moving rack having an optical passage ingress sensor, it is preferable that the maximum value of the amount of oblique movement at which switching over to the "oblique movement correction mode" is to be performed is set to the amount of oblique movement within a range in which the optical passage ingress sensor can fulfill its function.

[0112] Referring now to FIG. 33 shows an example using an optical passage ingress sensor to determine if a person or object moves between two adjacent partitions. In such an arrangement, In FIG. 33, light emitting sections 111are placed on the opposing faces of adjacent moving racks

101, 101 for emitting a light beam from one moving rack 101 toward the other moving rack 101. Facing these light emitting sections 111 on the opposing faces of the other moving racks 101 are disposed light receiving sections 112 for receiving the light beam. In the example of FIG. 33, on one of the left and right ends of the moving rack 101 is disposed the light emitting section 111 and on the other end the light receiving section 112.

[0113] If a person(s) or other obstacles enter the working passage formed between the two moving racks 101, 101, the light beam is blocked by the person(s) or other obstacles, and the ingress of the person(s) or other obstacles can be detected. Safety can be secured if all the moving racks are emergency-stopped in response to this detected signal. Such an optical passage ingress sensor has been known in the art of the moving rack, and the detailed description will be omitted.

[0114] For the optical passage ingress sensor to fulfill its function, it is required that a light beam emitted from a light emitting section 111 on one moving rack 101 can be received by a light receiving section 112 on the other moving rack 101. However, if the amount of oblique movement of the moving rack becomes large, the light axis of

the light beam emitted from the light emitting section 111 deviates, and the light receiving section 112 will fail to receive the light beam. This produces the same result as when the light beam is blocked by a person(s) or other obstacles, resulting in an emergency stop of the movements of all moving racks.

[0115] In addition, to return to a normal condition from the emergency-stopped state, the oblique movement of the moving rack needs to be corrected, for example, by human power, which is a troublesome work. Therefore, in accordance with another feature of the invention control is set such that it is switched over to the "oblique movement correction mode" if a certain amount of oblique movement is detected before the light receiving section 112 fails to receive the light beam from the light emitting section 111.

[0116] The optical passage ingress sensor may be arranged such that a light emitting section and a light receiving section are provided only on one moving rack, that a light beam emitted from the light emitting section is reflected by a mirror on the other moving rack, and that a light receiving element mounted thereon receives the reflected light beam.

[0117] Thus from the foregoing description it should be readily

apparent that the described embodiments provide moveable partitions and controls that permit smooth operation and parallel movement even when they are trackless and that provide safety in operation in avoiding encounters with unexpected objects without unnecessarily stopping the operation when an object is not actually there. Of course those skilled in the art will readily understand that the described embodiments are only exemplary of forms that the invention may take and that various changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.